Worksheet 4 Assembly language Answers

Task 1

The instruction set for the Little Man Computer (LMC) is shown in the Table below.

Mnemonic code	Instruction	Numeric code	Description
ADD	ADD	1xx	Add the contents of the memory address to the Accumulator
SUB	SUBTRACT	2xx	Subtract the contents of the memory address from the Accumulator
STA	STORE	3xx	Store the value in the Accumulator in the memory address given.
LDA	LOAD	5xx	Load the Accumulator with the contents of the memory address given
BRA	BRANCH (unconditional)	6xx	Branch - use the address given as the address of the next instruction
BRZ	BRANCH IF ZERO (conditional)	7xx	Branch to the address given if the Accumulator is zero
BRP	BRANCH IF POSITIVE (conditional)	8xx	Branch to the address given if the Accumulator is zero or positive
INP	INPUT	901	Input into the accumulator
OUT	OUTPUT	902	Output contents of accumulator
HLT	Halt	0	Stops the execution of the program.
DAT	DATA		Used to indicate a location that contains data.

1. The assembly language program below is written using the LMC instruction set.

```
        INP
        STA x
        INP
        STA y
        INP
        ADD x
        SUB y
        OUT
X       DAT
y       DAT
```

State what the output is when the user inputs 5, 7 and 13. Answer: 11

2. The assembly language program below is written using the LMC instruction set.

```
        INP         input n=1 to the accumulator
        STA n       store value in n
        INP         input 6 to accumulator
        STA x       store in x
        STA z       store in z
        INP         input 4 to the accumulator
        SUB n       subtract 1 leaving 3 in accumulator
        SUB n       subtract 1 leaving 2 in accumulator
        STA y       store 2 in y
loop    LDA x       load x into accumulator
        ADD z       add 6 to accumulator
        STA x       store in x
        LDA y       load y
        SUB n       subtract n
        STA y       store in y
        BRP loop    branch if accumulator is positive or zero to loop
        LDA x       load x
        OUT         output contents of accumulator
n       DAT
x       DAT
y       DAT
z       DAT
        HLT
```

(a) State what the output is when the user inputs 1, 6, 4. Output is 24

Use the trace table below to help you.

acc	n	x	z	y
1	1			
6		6	6	
4				
3				
2				2
6				
12		12		
2				
1				1
12				
18		18		
1				
0				0
18				
24		24		
0				
-1				-1
24				

(b) State the purpose of the program.

It multiplies x by y and outputs the result.

In more sophisticated processors, there are several general purpose registers and it is clear from this example how useful that is! x, y, z and n could then all be held in separate registers. n is simply a counter, counting down from 4-2 until it becomes negative, which ends the loop.

3. Write an assembly code program to input two numbers x and y and output the maximum.

```
     INP        input first number to the accumulator
     STA x      store value in x
     INP        input second number to accumulator
     STA y      store value in y
     SUB x      subtract x
     BRP ymax   if y-x > 0 branch to ymax
     LDA x
     OUT        output x
     HLT
ymax LDA y
     OUT        output y
     HLT
x    DAT
y    DAT
```

Extension Task

Run all the programs in Task 1 on the LMC computer at
http://peterhigginson.co.uk/LMC/

Task 2

4. The contents of memory cells 51-58 are as shown in the table below.

Memory location	Contents
51	2
52	55
53	51
54	14
55	20
56	3
57	52
58	53

Table 1

State what will be the contents of the accumulator after each of the following operations:

(a) `load immediate 53` Answer: 53

(b) `load direct 53` Answer: 51

(c) `load indirect 53` Answer: 2

(d) `load indexed R0` (Assume R0 contains 3 and the Index register contains 50)

Answer: 51 (i.e. the contents of location 53)